299-W18-71 (A7554)
Log Data Report

Borehole Information:

Borehole:	299-W18-71 (A7554)		Site:	216-Z-12 Crib	
Coordinates (WA St Plane)		GWL[1] (ft):	None	GWL Date:	02/14/06
North (m)	East (m)	Drill Date	TOC Elevation	Total Depth (ft)	Type
135452.728	566362.055	03/67	685.3 ft	20	Cable

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Welded Steel	0.6	6 1/4	6	1/8	0.6	20

Borehole Notes:

Casing diameter and casing stickup measurements were acquired by the logging engineer using a caliper and steel tape. A visible dent is present on the casing near the opening, and is out-of-round. Measurements were rounded to the nearest 1/16 in. All logging measurements are referenced to the top of casing.

Kasper (1982) reports six shallow wells (70 through 75) were drilled in the 216-Z-12 crib in 1967 to determine if discharged waste was being dispersed over the entire bottom area of the crib. "The wells were drilled until alpha contamination was encountered, or a few feet below where it could be expected to be encountered." (quote from Crawley, 1967; reference unavailable). Using a portable radiation survey instrument ("poppy"), activity was detected in well 71 at the bottom of the borehole (about 19.6 ft) at greater than 40,000 dpm. This well is located along the distribution pipe in the northern third of the crib, at approximately 19.5 ft in depth (probably from ground surface). It was concluded that the flow of the waste to the crib was insufficient to distribute the liquid over the entire crib bottom. As a result, in July 1968, a diversion pipe was installed in the crib, bypassing the first 100 ft of the distributor pipe, south of the location of borehole 71. From July 1968 to May 1973, when the crib was retired, waste was discharged only to the southern two-thirds of the crib (Kasper 1982).

Logging Equipment Information:

Logging System:	Gamma 4A		Type:	SGLS (35%) 34-TP20893A
Effective Calibration Date:	05/11/05	Calibration Reference:	DOE/EM-GJ891-2005	
		Logging Procedure:	MAC-HGLP-1.6.5, Rev. 0	

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1				
Date	03/08/06				
Logging Engineer	Spatz				
Start Depth (ft)	21.0				
Finish Depth (ft)	1.0				
Count Time (sec)	200				
Live/Real	R				
Shield (Y/N)	N				
MSA Interval (ft)	1.0				
ft/min	N/A				
Pre-Verification	DA101CAB				
Start File	DA111000				

Log Run	1				
Finish File	DA111020				
Post-Verification	DA111CAA				
Depth Return Error (in.)	0.0				
Comments	No fine-gain adjustment.				

Logging Operation Notes:

Logging was conducted March 8, 2006 using SGLS logging system Gamma 4A. Pre- and post-survey verification measurements for the SGLS employed the Amersham KUTh verifier with serial number 115. All measurements were acquired with a centralizer installed on the sonde. The top of casing is the reference depth for log data. The maximum depth achieved was 21.1 ft. Repeat logging was not performed in this borehole.

Analysis Notes:

Analyst:	Pope/Henwood	Date:	03/08/07	Reference:	GJO-HGLP 1.6.3, Rev. 0

SGLS pre-run and post-run verification spectra were collected at the beginning and end of the day. The verification spectra were within acceptance criteria.

Log spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source file G4Amay05.xls). Log data were corrected for a casing thickness of 1/8-in.Results and Interpretations:

Results and Interpretations:

Elevated gamma activity is observed from 20 to 21 ft near the bottom of the borehole. Cs-137 (also observed at 19 ft), Np-237, Am-241, Pu-239, and U-237 are identified, and Pu-240 and Pu-241 are inferred. In the spectra at 20 and 21 ft, an additional decay gamma line at 1274 keV is identified that may be attributed to alpha-neutron (α,n) reactions with F-19. The neutron-capture gamma line associated with H is also identified. Higher in the borehole, Cs-137 is identified at low concentrations (0.1 to 0.2 pCi/g) from 1 to 2 ft, and at 11 ft. Evidence of internal Am-241 contamination of the borehole exists from 4 to 12 ft. This evidence is based on detection of the 60 keV gamma ray, which is generally attenuated by the steel casing.

Am-241 is detected at 20 and 21 ft. The maximum concentration is measured at approximately 630,000 pCi/g at 21 ft. Gamma rays at approximately 662, 722, and 208 keV are detected that represent Am-241. Cs-137 emits a 661.66 gamma ray that cannot be distinguished from the 662.40 gamma ray emitted from Am-241. The energy peak at 722.01 keV is used to establish the presence of Am-241 rather than Cs-137. In this borehole the 722.01 keV energy peak is used to determine the Am-241 concentration. When comparing the assays for Am-241 using the 662 and 722 keV energy peaks, there appears to be residual counts in the 662 keV energy peak that may be attributed to Cs-137. On the basis of the 722.01 keV assay, counts from the 662.40 keV energy peak were subtracted which yields the approximate contribution from Cs-137.

Using this approach, Cs-137 is detected at 20 and 21 ft. The maximum concentration of 300 pCi/g is measured at 21 ft. However, it is presumed that few, if any, fission products would reside in a waste stream originating from PFP. Other possibilities for the existence of 662 keV gamma rays are being investigated.

The Am-241 concentrations derived from the 208.01 keV gamma line are significantly over estimated. A 208.00 keV gamma line that results from the decay of U-237 (daughter of Pu-241), interferes with the 208.01 keV gamma line caused by the decay of Am-241. For purposes of this report, it is assumed that all of the counts in the 208 keV energy peak that cannot be attributed to Am-241, reflect decay of U-237. Assuming the waste stream is aged (e.g., 40 years or more), U-237 has grown into equilibrium with its parent Pu-241 whereby the activity of the

daughter product will equal the activity of the parent. It is determined Pu-241 exists at 21 ft at a concentration of approximately 1.3 million pCi/g.

An evaluation of Pu-239 peaks determined the 345.01 energy peak has no obvious interferences, but is not identified at 20 ft. The 129.296 keV energy line is also free from interferences from Am-241 and Np-237, but is below the calibration range for this instrument. The 413.713 keV peak is used to assay Pu-239, because it is stronger than the 375.054 keV line, and is determined to be less affected by interference from Am-241 and Np-237, based on independent assays using the 722.01 and 312.17 keV gamma peaks, respectively. Contributing concentrations from Am-241 (based on the 722.01 keV line) and Np-237 (based on the 312.17 keV line) were subtracted from the 413 keV line. Based on the remaining counts in the 413 keV line, the calculated concentrations for Pu-239 at 20 and 21 ft are 159,000 and 1,287,000 pCi/g, respectively.

No direct assay for Pu-240 using the SGLS is possible. However, it is virtually certain it exists where Pu-239 and Pu-241 are detected.

Np-237 as determined from a decay product (Pa-233 at 312 keV) is detected at 20 and 21 ft at concentrations of approximately 22 and 59 pCi/g, respectively.

"Thorium disequilibrium" has been reported in other boreholes in the 216-Z-12 Crib, which suggests the presence of contamination associated with thorium irradiation. Neutron activation of Th-232 and subsequent beta decay yields U-233. U-232 is also created by a (n,2n) reaction and beta decay. U-233 emits few detectable gamma rays. Eventually, later daughters in the decay chain may build in to detectable amounts.

Decay of U-232 yields Th-228, which occurs below Ac-228 in the Th-232 decay chain. Ac-228 is sometimes used to assay natural Th-232, using primarily the 911.20 keV gamma line. Tl-208 is more commonly used to assay Th-232, because of the high-energy gamma at 2614.53 keV. If U-232 is part of the waste, there is a notable increase in Tl-208 (2614 keV peak) concentration without a comparable increase in Ac-228 (911 keV peak) concentration. At 20 and 21 ft in this borehole, Tl-208 concentrations are about double and triple, respectively, those measured in the rest of the borehole. The 911.21 keV peak (Ac228) is not observed at 20 or 21 ft, such that direct comparison of Ac-228 and Tl-208 concentrations is not possible. The limited evidence of thorium disequilibrium at the bottom of the borehole is not, on its own, conclusive of the presence of U-232, but it is consistent with findings in other nearby boreholes in the 216-Z-12 Crib. If U-232 is present here, then U-233 is almost certainly present. U-233 does not have detectable gamma rays for a direct assay and daughter products have not had sufficient time to build in such that detectable gamma rays are detectable at low concentrations.

The 59.54 keV gamma energy peak of Am-241 is detected from 4 to 12 ft. The peak has a yield of 35.9%, but is very highly attenuated by the steel of the borehole casing walls. It is therefore normally not observed unless the Am-241 is either on the inside of the casing, or is at such high concentrations that a measurable proportion of the 60 keV gammas penetrate the casing. At high concentrations, the 722.01 and 662.4 keV lines (both substantially lower-yield gammas) should be detected also, but are not seen at these depths. The conclusion, therefore, is that this observation is consistent with internal Am-241 contamination. The highest count rate of about 3 cps occurs at 6 ft. Am-241 cannot be quantified using the 60 keV energy peak, because it is outside the calibration range for this tool.

Evidence of a significant neutron flux is apparent in the spectra at 20 and 21 ft. Neutrons can be generated by interactions of alpha particles with light elements (α,n reactions) or, to a lesser degree, from spontaneous fission, primarily from even-numbered Pu isotopes. Positive evidence of a substantial neutron flux is shown in the spectra by a hydrogen capture gamma ray at 2223.25 keV.

Another reaction, F-19 (α,ng) Na-22, yields a prompt gamma at approximately 1274 keV, a Na-22 decay-gamma ray at 1274.53 keV (99.94% yield) and a positron at 511 keV. A 1274.44 keV gamma ray also occurs from the decay of Eu-154, but no corroborating peaks for Eu-154 are observed, and the gamma ray is therefore attributed to the fluorine prompt gamma and Na-22 decay. The half-life of Na-22 is short (2.6 years), but will continue to be produced as long as sufficient fluorine concentrations and alpha activity exist.

These (α,n) reactions may indicate specific waste forms. Fluorine is mentioned in the literature as having uses in the processing and refinement of the Pu product at the Plutonium Finishing Plant. Fluorine has a large alpha-capture

cross-section, approximately 100 times greater than either O or N. The presence of gamma rays originating from (α,n) reactions on F, together with higher neutron activity, strongly suggests that at least part of the Pu is present as PuF_4.

Westinghouse Hanford Company (WHC) logged this borehole in 1993 with the Radionuclide Logging System (RLS) to a depth of 18.5 ft from ground surface. WHC reported Cs-137 from 0 to 2 ft at an activity of 0.2 to 0.3 pCi/g, and from 17 to 18.5 ft with a maximum concentration of about 14 pCi/g at 18.5 ft. Additionally, they report having seen evidence of Pa-233 (312 keV peak) at 18.5 ft, and Am-241 (60 keV peak) sporadically from 1 to 14 ft. Current logging with the SGLS is in reasonable agreement with the 1993 RLS log. The SGLS log apparently achieved a greater depth (1-2 ft) than the RLS, and transuranics are noted.

List of Log Plots:

Man-made Radionuclides
Natural Gamma Logs
Combination Plot
Total Gamma and Dead Time
SGLS/RLS Manmade Comparison

References:

1982. Kasper, R.B. *216-Z-12 Transuranic Crib Characterization: Operational History and Distribution of Plutonium and Americium*, RHO-ST-44, Rockwell International, Richland, Washington.

[1] GWL – groundwater level

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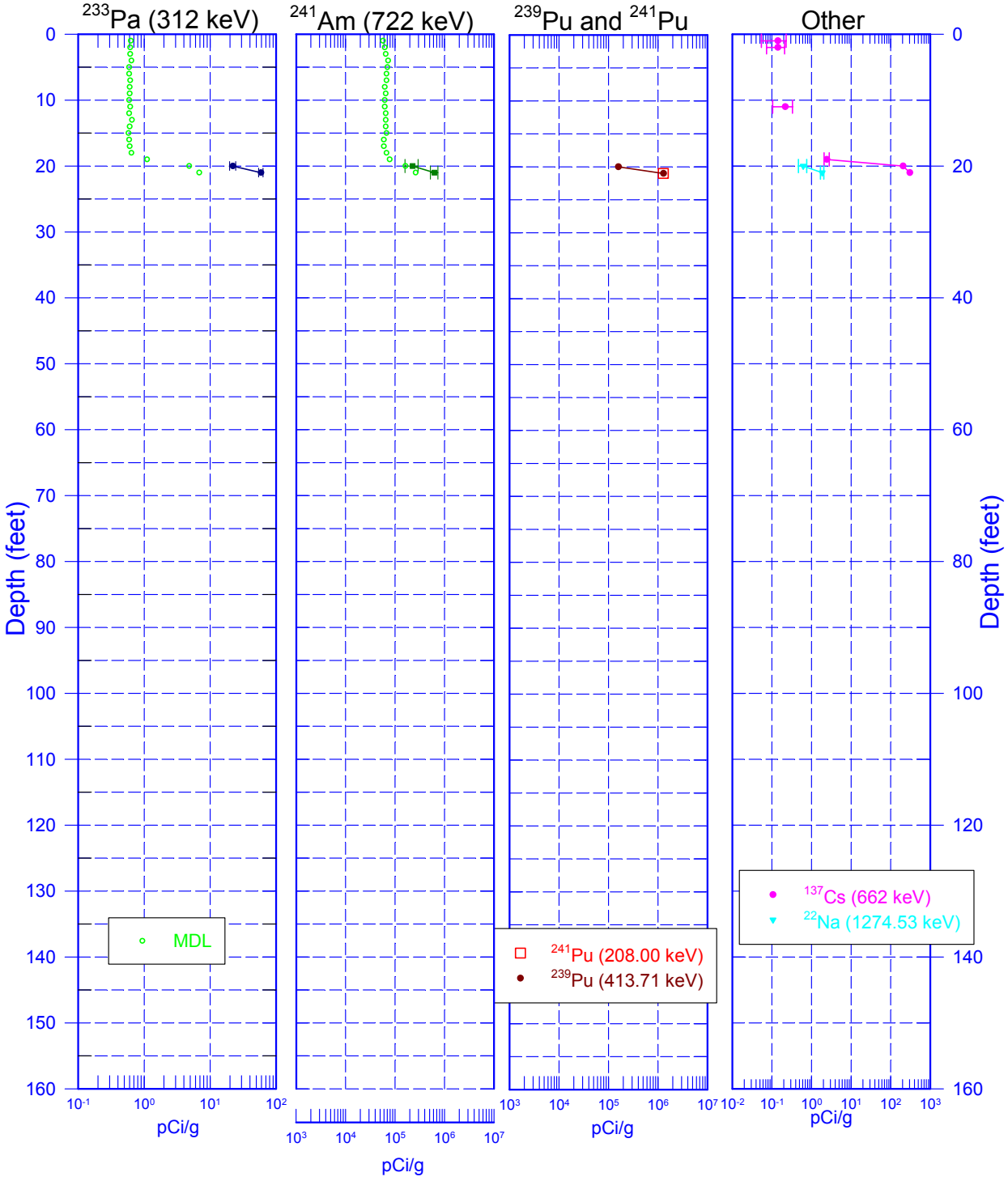
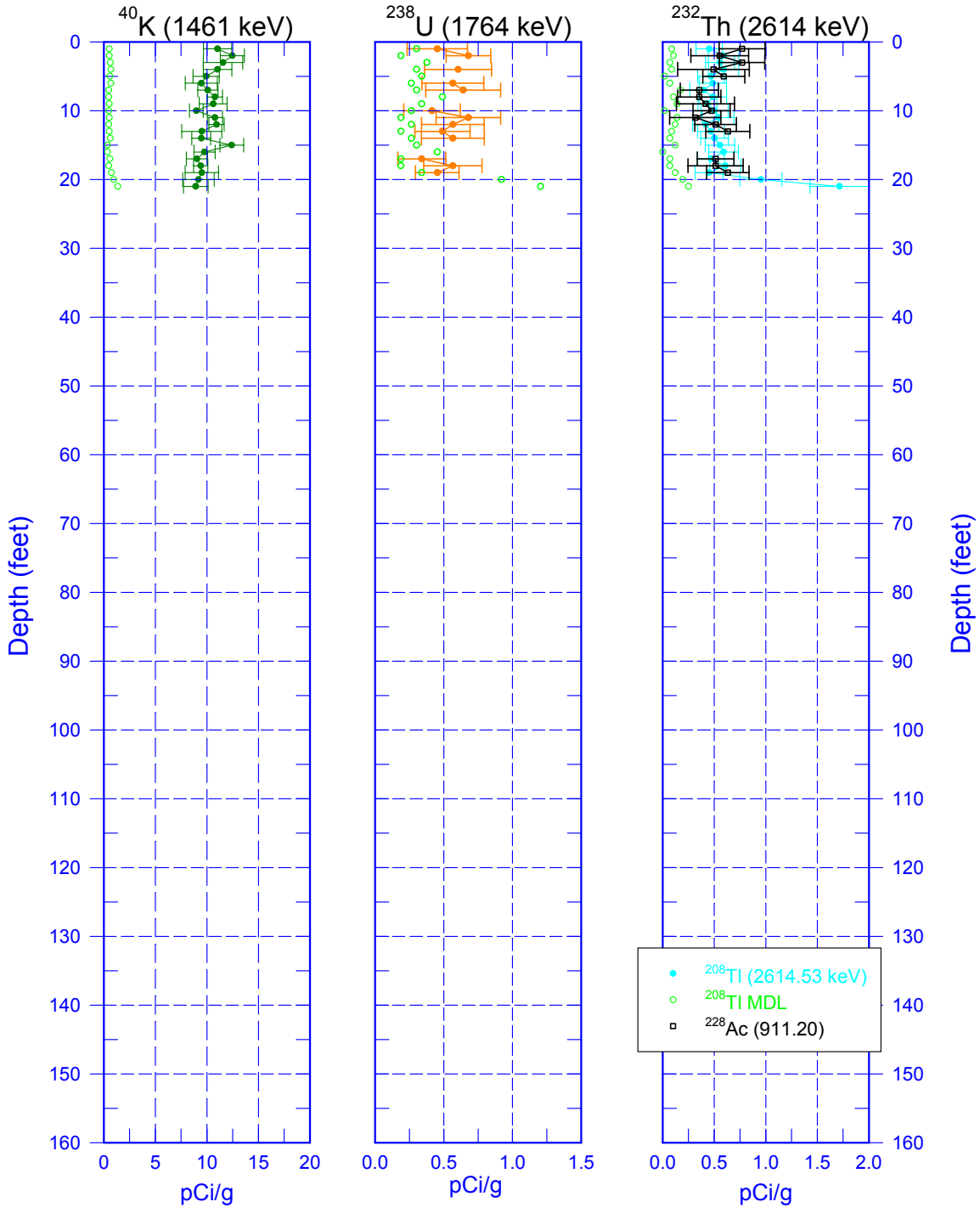
Manmade Radionuclides



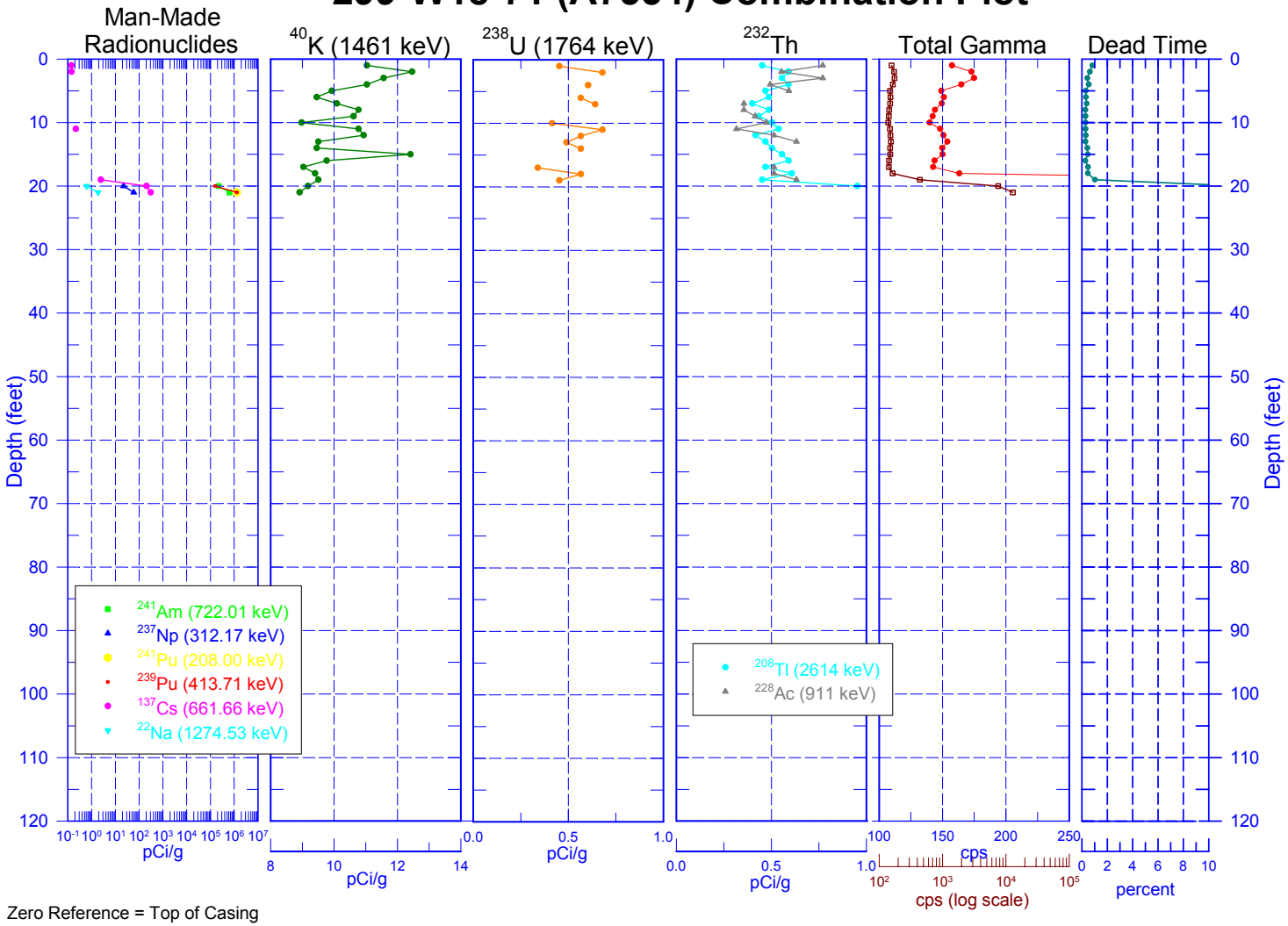
Zero Reference = Top of Casing

299-W18-71 (A7554)
Natural Gamma Logs



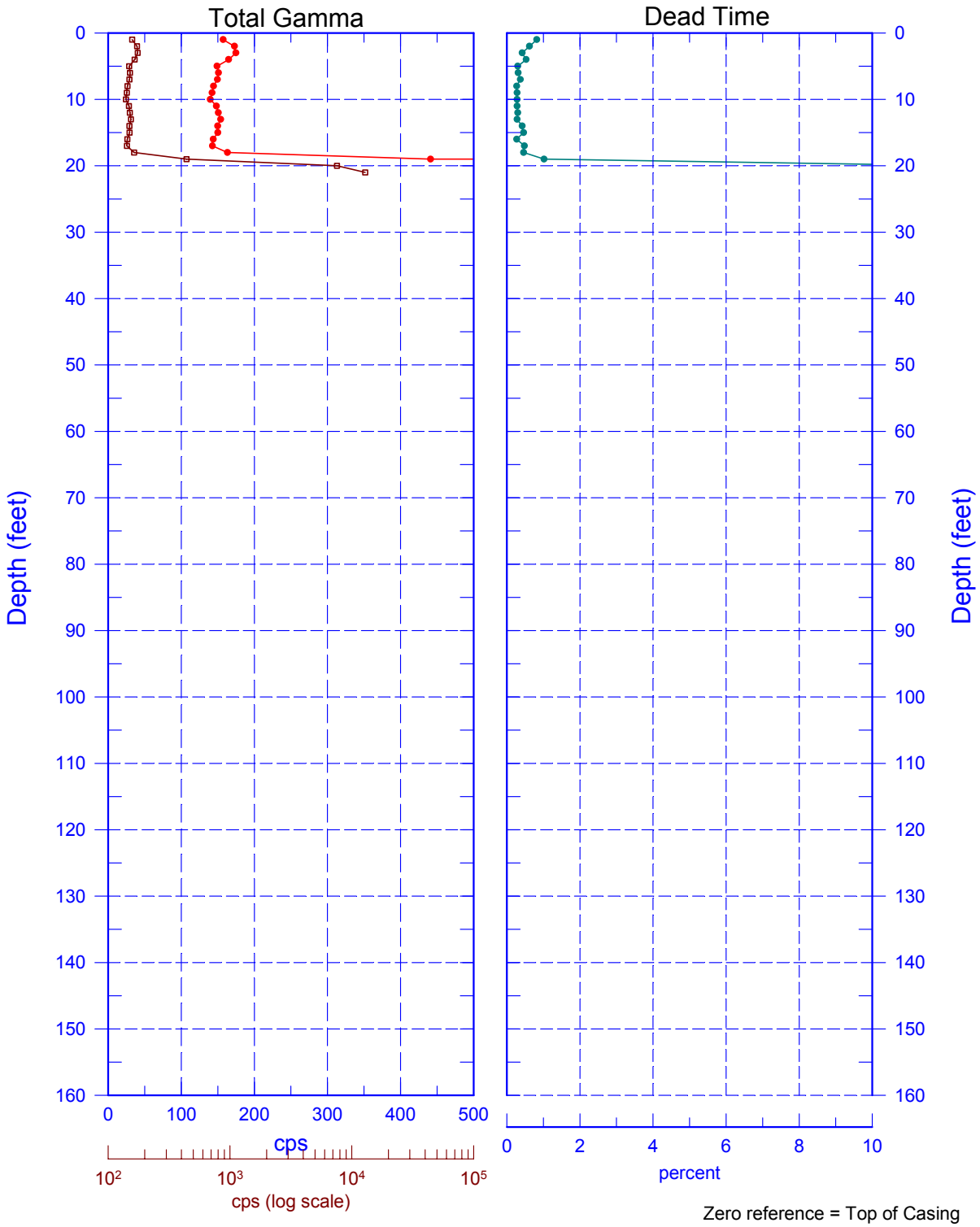
Zero Reference = Top of Casing

299-W18-71 (A7554) Combination Plot



Zero Reference = Top of Casing

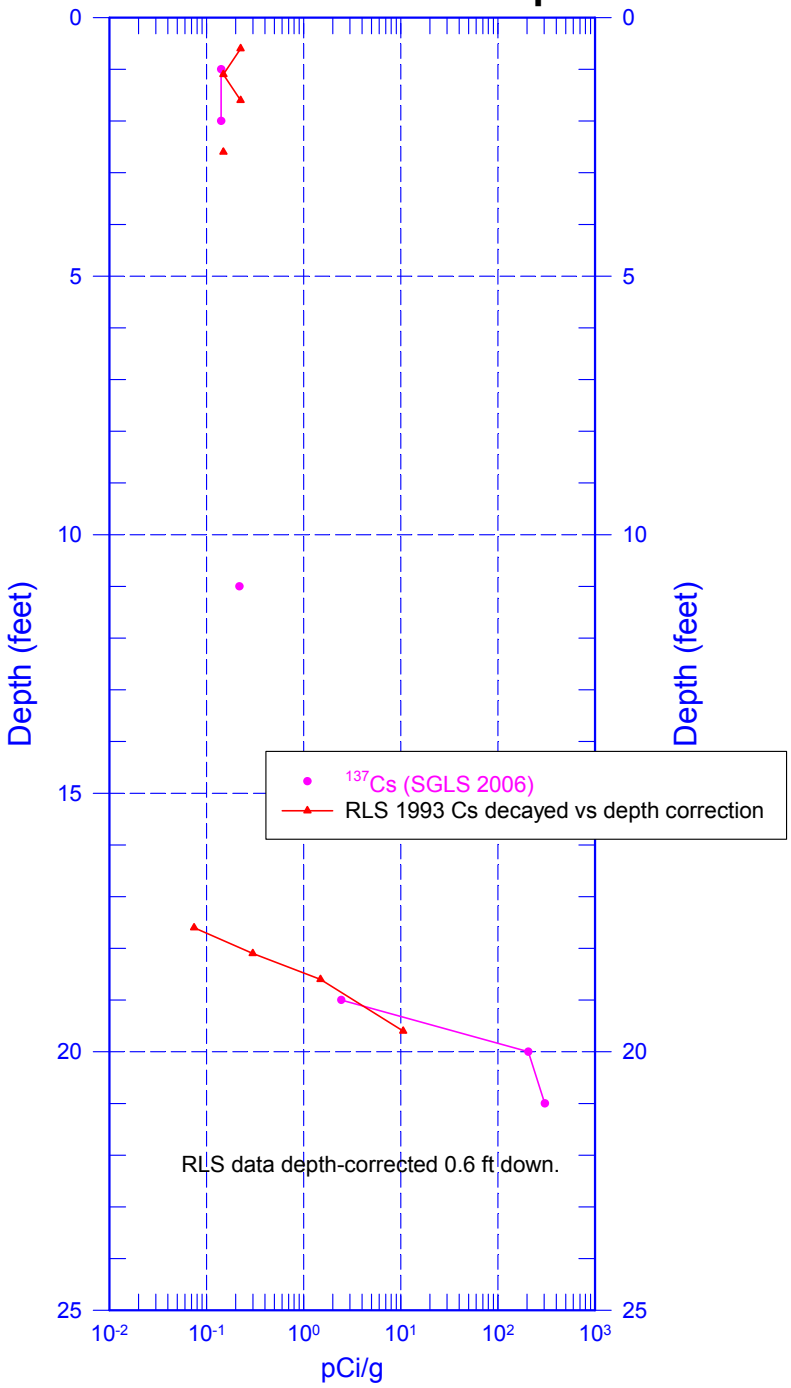
299-W18-71 (A7554)
Total Gamma & Dead Time



Zero reference = Top of Casing

299-W18-71 (A7554)

SGLS/RLS Manmade Comparison



Zero Reference = Top of Casing